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THE DISTRIBUTION OF NEMATODE PARASITES WITHIN THE STOMACH OF THE WESTERN GREY KANGAROO, *MACROPUS FULIGINOSUS*

by D. PAMMENT, I. BEVERIDGE & R. B. GASSER

Summary

PAMMENT, D., BEVERIDGE, I. & GASSER, R. B. (1994). The distribution of nematode parasites within the stomach of the western grey kangaroo, *Macropus fuliginosus*. *Trans. R. Soc. S. Aust.* **118**(3) 187-196, 30 November, 1994.

The distribution of strongylid nematodes in the stomachs of ten western grey kangaroos (*Macropus fuliginosus*), from Hattah, Victoria indicated that each genus encountered, *Cloacina*, *Rugopharynx*, *Labiostrongylus*, *Popovastrongylus* and *Filarinema*, occupied a specific region within the stomach. Their distribution bore no relationship to histologically defined regions of gastric mucosa, and the pathological changes detected in the mucosa were related more closely with mucosal type than with local nematode densities. The anatomical and histological features of the stomach of *M. fuliginosus* are described.

KEY WORDS: Nematoda, Strongyloidea, *Macropus*, Macropodidae, distribution, gastric anatomy.

Introduction

The differential localisation of multiple, closely-related parasitic nematode species within the gastrointestinal tract of their hosts has been investigated extensively in the case of the oxyuroid parasites of tortoises (Petter 1963, 1966; Schad 1963). Niche diversification has been demonstrated on the basis of differences in the linear and radial distribution of nematode species and in their feeding behaviour. Inglis (1968) suggested that because of the complex anatomy of their stomachs and the diversity of nematode species harboured within them, the kangaroos represented an equally suitable group of hosts for studying the coexistence of congeneric and confamilial nematode species within the same host. Studies undertaken to date support Inglis' (1968) suggestion, but have been limited to the red kangaroo, *Macropus rufus* (see Mykytowycz 1964; Dudzinski & Mykytowycz 1965; Arundel *et al.* 1979) and the tammar wallaby, *Macropus eugenii* (see Smales & Mawson 1978a). In this study, the distribution of nematodes within the stomach of the western grey kangaroo, *Macropus fuliginosus*, was investigated and relationships between this distribution and gastric mucosal histology examined. Pathological changes in the gastric mucosa were also investigated. Examination of *M. fuliginosus* allowed analysis of the relationships of four confamilial genera, and in the case of one genus, *Cloacina*, the comparative distributions of several congeneric species.

Methods

Collection of material

Stomachs were obtained from ten western grey kangaroos, *Macropus fuliginosus*, culled at Hattah Lakes National Park (34°45'S, 142°15'E), Victoria in November 1990. Animals were shot, weighed and sex and body measurements were recorded. The stomach was removed rapidly from the carcass, the oesophagus

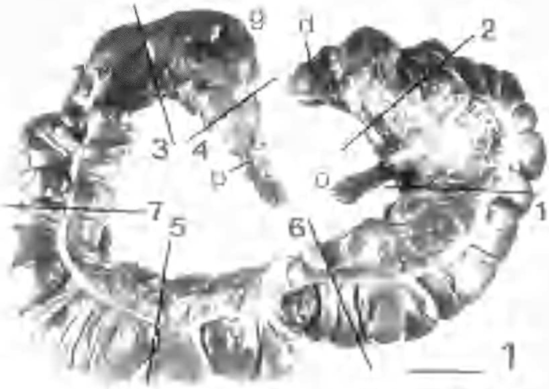

Fig. 1. Stomach of *Macropus fuliginosus*, unopened. Lines and numbers indicate the positions of ligatures and the order in which they were applied.
Anatomical landmarks shown are the oesophagus (o), the proximal diverticulum (d), the gastric pouch (g) and the pylorus (p). Scale bar: 5 cm.

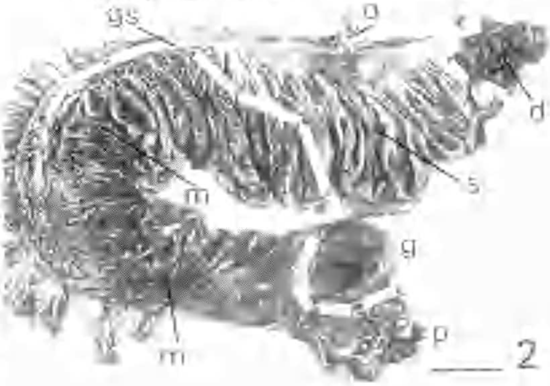

Fig. 2. Stomach of *Macropus fuliginosus*, opened to show distribution of the principal types of mucosal surfaces, delineated by white broken lines: the glandular mucosa of the proximal diverticulum (d), the squamous epithelium of the saccular and tubular forestomach (s), proximal and distal to the oesophagus (o) and the gastric sulcus (gs), the glandular mucosa of the tubular forestomach (m), the mucosa of the gastric pouch (g) and pylorus (p). Scale bar 5 cm.

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and pylorus were tied with string, numerous small punctures were made in the stomach wall and the entire stomach was immersed in 50 litres of neutral buffered 15% formol saline (6% formaldehyde).

In the laboratory, stomachs were washed in water to remove formalin, photographed and weighed, then subdivided with ligatures and opened. Anatomical nomenclature for the regions of the stomach follows Hume (1982). The ligatures were placed in the following order (Fig. 1): at the level of the oesophageal opening (1), midway between the oesophageal opening and the extremity of the saccular forestomach (2) at the junction of the tubular forestomach with the gastric pouch (3) and at its junction with the pyloric antrum (4). Subsequently, the tubular forestomach was subdivided by three ligatures (5-7) placed equidistantly. The content from each section was removed and weighed. Within each section of the stomach, a transverse strip of tissue was removed, embedded in paraffin, sectioned at a thickness of 3μm, and stained with haematoxylin and eosin for histological examination. The extent of the different epithelial regions of the stomach was determined by cutting out the entire squamous, mucus-secreting, glandular (proximal diverticulum), gastric and pyloric regions and weighing them. The average weight per cm^2 of each mucosal type was determined by weighing 2 cm^2 portions of each mucosal type, and the area occupied in each stomach was calculated by dividing the two.

As a control for histopathological examination, a single adult *M. fuliginosus* from Healesville Sanctuary, killed for other reasons, was examined. This animal had been treated regularly with anthelmintics to remove nematodes prior to death by intravenous injection of a barbiturate. Portions of gastric mucosa were fixed immediately in 10% neutral buffered formol saline (4% formaldehyde) and were processed for histological examinations as described above.

Parasitological observations

The total number of nematodes in each section of the ten stomachs was estimated by a dilution technique (Clark *et al.* 1971) and the number of each species present determined by clearing all nematodes in the appropriate subsample in lactophenol and identifying them to species under a compound microscope.

To establish whether or not parasite distribution was affected by this method of fixation, two additional stomachs collected were ligated with string at six points along their length before being immersed in formaldehyde solution.

Representative specimens of each nematode species have been deposited in the South Australian Museum (SAM), Adelaide. Nomenclature of species of the genera *Labiostrongylus* and *Cloacina* is currently under revision. For this study, the species names applied are the same as those used by Beveridge & Arundel (1979).

Results

Gross anatomy of the stomach

The gross anatomy of the stomach of *M. fuliginosus* (Figs 1, 2) resembles that of *M. giganteus* (Langer *et al.* 1980; Dellow 1982). Wet weight of stomach contents (Table 1) in individual sections demonstrated that sections 1 and 2 (= the saccular forestomach [Langer *et al.* 1980]) constituted 22.3% of total stomach weight, sections 3-6 constituted 73.5% of total stomach weight (= tubular forestomach), and sections 7 and 8 constituted 4.3% of total stomach weight (= hind stomach). The gastric sulcus was prominent and extended halfway along the tubular forestomach.

Relative surface areas occupied by different epithelial types (Table 2) demonstrated that squamous and mucus-secreting epithelia were the two predominant types. The proximal diverticulum of the saccular forestomach was lined by a distinctive, glandular epithelium. The remainder of section 1 and section 2 of the stomach is lined by squamous epithelium. Apart from the gastric sulcus which is covered with a squamous epithelium, sections 3 to 6 are lined with cardiac epithelium. Section 7 has an acid-secreting fundic epithelium, while section 8 is lined by a distinctive pyloric epithelium.

TABLE 1. *Wet weights of content of eight different regions of the stomach of ten* Macropus fuliginosus *from Hattah Lakes National Park, Victoria.*

Stomach Section No.	Mean weight (g)	Range (g)	Standard Deviation	Proportion of Total Weight (%)	Predominant Epithelial Type
1*	89	46-151	32	4.2	s (squamous)
2	387	55-638	322	18.1	s
3	348	109-548	134	16.3	m (mucous)
4	465	145-1203	299	21.8	m
5	428	128-834	235	20.0	m
6	329	71-774	292	15.4	m
7	78	8-169	50	3.7	g (gastric)
8	12	0-35	12	0.6	p (pyloric)
Total	2136	712-4670	–	100	

* For key to stomach sections, see Fig. 1.

TABLE 2. *Area, as a percentage of the total, occupied by different epithelial surfaces in the stomach of ten Macropus fuliginosus from Hattah Lakes National Park, Victoria.*

Epithelial Type	*Percentage of Total Stomach Area Occupied*	*Standard Deviation*
Squamous	31	11
Mucus secreting (tubular forestomach)	53	10
Glandular (anterior gastric diverticulum)	5	1
Gastric	5	3
Pyloric	5	1

Histological features of gastric epithelia

Squamous epithelium

This epithelium ranged from 80-320 μm in thickness. Basal cells in this region were irregularly cuboidal in shape, nuclei were relatively small, basophilic and had a prominent dark nucleolus. The cytoplasm was compact, eosinophilic and cell margins were indistinct. In the mid-region of the epithelium, cells were enlarged, cell margins were readily distinguishable, irregularly cuboidal or polygonal in shape with an enlarged, pale nucleus and prominent nucleolus. Margination of chromatin was evident in most nuclei. Towards the lumen of the stomach, cells became squamous and the cytoplasm more densely eosinophilic. The nuclei were indistinct. On the surface itself, flattened keratinised cells were visible sloughing into the lumen, and in several sections, a distinct layer of adherent bacteria was evident, closely applied to the superficial keratinised layer. The squamous epithelium was folded, with interdigitations of the lamina propria projecting into the base of the folds.

Cardiac epithelium

This epithelium was up to 600 μm thick and was composed of elongate, parallel glands 45 μm in width. The cells lining the glands were cuboidal to columnar, 25 μm in length and 10 μm wide. The glands consisted of two distinct cellular components. The cytoplasm of cells at the base of the glands was faintly eosinophilic and had a foamy appearance; cell boundaries were distinct. Nuclei were situated at the bases of the cells; they were slender and elongated, and usually demonstrated emargination of chromatin and a prominent, small nucleolus. Cells in the mid-region of the glands were eosinophilic and the cytoplasm had a granular appearance. Nuclei were large and rounded with a prominent nucleolus and punctate, emarginate chromatin. Surface epithelial cells were longer and more slender than cells within the glands. The lamina propria was very narrow and was bounded internally by a broad lamina muscularis mucosae.

Epithelium of the proximal diverticulum

This epithelium of the proximal diverticulum of the sacciform forestomach differed from that of the cardiac region (Fig. 3). The epithelium was extremely thick, up to 1.8 mm, and was composed of elongate glands, up to 1.55 mm long and 0.4 mm wide, which became sinuous towards the base. Cells lining the glands were cuboidal in shape, approximately 15μm by 10μm in size with a highly eosinophilic cytoplasm. The nuclei were small and were situated at the base of the cell with emargination of chromatin or with chromatin distributed in a punctate pattern, and a small nucleolus. The lumina of glands were dilated and contained a highly eosinophilic fluid, presumably secreted by the glands.

Fundic epithelium

This epithelium was 1.55 mm thick and was composed of parallel, elongate glands. The histological appearance of the glands was similar to that found in other mammals, with elongate surface cells, cuboidal mucous neck cells at the anterior ends of the glands, and chief cells and parietal cells towards the base.

Pyloric epithelium

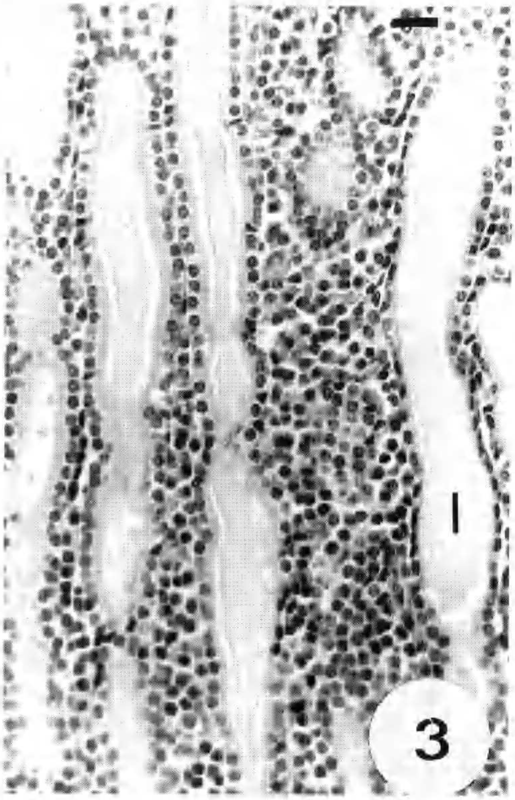
This epithelium was 1.2 mm thick and consisted of groups of very long slender glands curving inward towards the stomach lumen, with slightly sinuous bases. Cells at the basal region were cuboidal to columnar, with pale, foamy, eosinophilic cytoplasm, prominent nuclei with emargination of chromatin and a large nucleolus. In the mid-region of the glands, cells tended to be low cuboidal in shape with a more eosinophilic cytoplasm than cells at the base. The lamina propria was narrow and a prominent lamina muscularis mucosae was present immediately below the base of the glands.

Histopathological changes in the epithelia

In spite of the large numbers of nematode parasites present in the stomachs of kangaroos, no gross pathological changes were observed in the mucosa.

The squamous epithelium demonstrated few histopathological changes. Occasional small clusters of lymphocytes and macrophages were evident in the mid-region of the epithelium, or in the lamina propria (Fig. 4). Eosinophils were occasionally prominent in the lamina propria. Accumulations of inflammatory cells were visible, most frequently close to the junction of the squamous and cardiac epithelia.

The glands of the cardiac region were intact histologically and no developing nematodes were seen within glands. The lamina propria, however, was diffusely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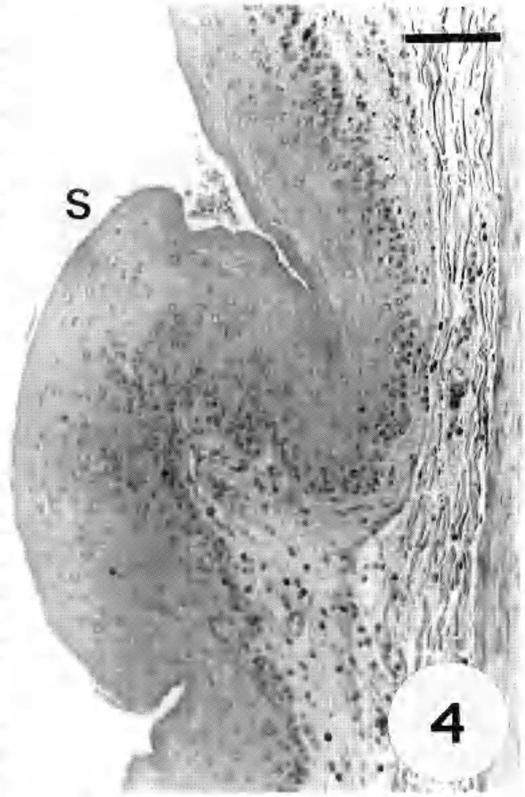
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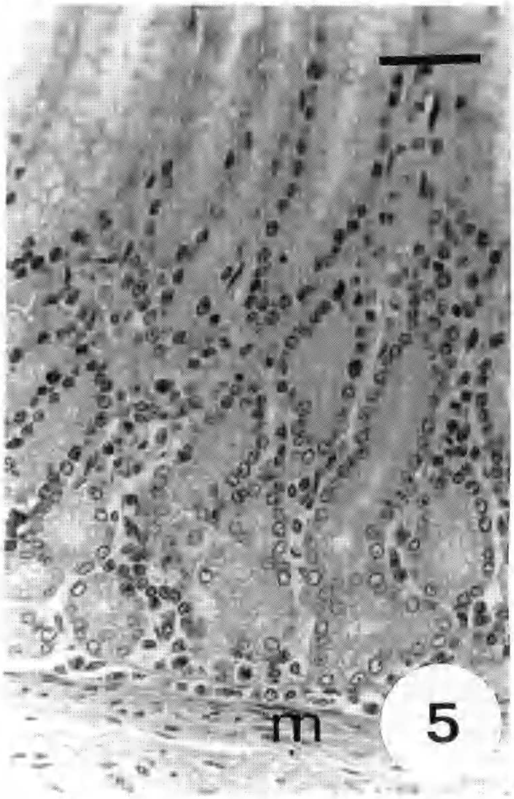
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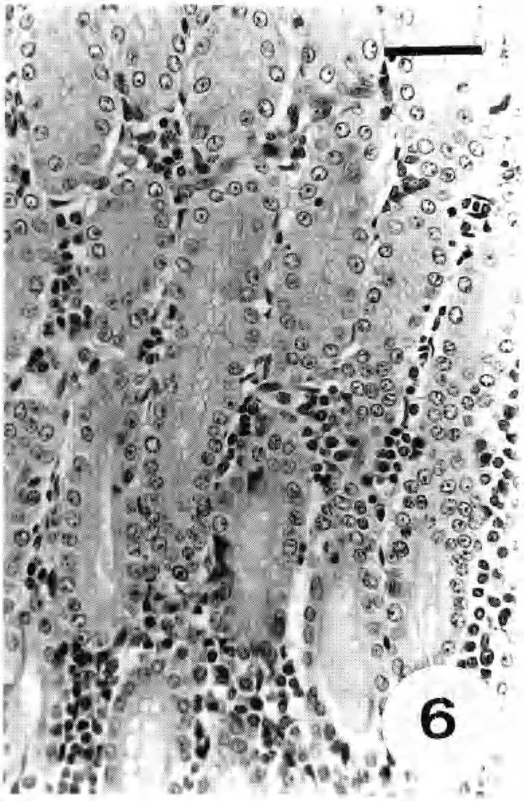
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infiltrated with mononuclear cells and granulocytes, principally eosinophils, with occasional large, focal accumulations of cells (Figs 5, 6). The submucosa was also uniformly infiltrated with the same inflammatory cells.

The proximal diverticulum invariably exhibited prominent infiltrations of the lamina propria with mononuclear cells, predominantly plasma cells, and lymphocytes, with a few eosinophils, sometimes to the extent that inflammatory cell accumulations obliterated individual glands (Fig. 3). In spite of the sometimes intense but chronic inflammatory reaction, very few nematodes were seen within glands. Those encountered were within or just below the epithelium and were surrounded by large accumulations of inflammatory cells. The fundic mucosa exhibited no significant pathological changes. The pyloric mucosa was histologically normal in most animals, but in several kangaroos, the megalo-schizonts of a coccidium developing towards the base of the glands obliterated numerous glands in the vicinity. As common as the schizonts were areas of necrosis and inflammatory cell debris indicating a site where a schizont had ruptured to release merozoites. An intense inflammatory reaction surrounded megalo-schizonts, characterised by large numbers of neutrophils and eosinophils.

Numbers and distribution of nematodes

The numbers of nematode parasites found in each of the 10 kangaroos examined are shown in Table 3.

The distribution of nematode species and genera in terms of absolute numbers in each section are shown in Figs 7-8. Expressing the results as densities (worms per g of stomach content) produced similar results, with the sole exception of section 1 of the stomach, in which densities of *Cloacina* spp. were higher than in other sections. Distributions of the genera differed. *Cloacina* spp. occupied the anterior sections (1-4) of the stomach, *Labiostrongylus kungi* and *L.* cf. *bipapillosus* (*sensu* Beveridge & Arundel 1979) occupied a relatively restricted region in the third segment, and *R. australis* and *P. pearsoni* occurred in sections 3-6 of the tubular forestomach. Very few nematodes were detected in regions 5-6 of the tubular forestomachs. In the gastric pouch (section 7), the only nematode species encountered was *Filarinema australis*. This is a new host record. *F. australis* was found in two animals, with two nematodes in each animal. No nematodes were found in section 8. Comparison of data from these 10 kangaroos with those from the two animals whose stomachs had been ligated prior to fixation revealed no differences in the distribution of parasites within the stomach.

TABLE 3. *Numbers of helminth parasites in the stomachs of ten* Macropus fuliginosus *from Hattah Lakes National Park, Victoria.*

Kangaroo No.	*Cloacina* spp.	*Labiostrongylus* spp.	*Rugopharynx australis*	*Popovastrongylus pearsoni*
1	480	15	37,990	0
2	3.300	560	73,000	1,060
3	1,400	15	80,870	5.380
4	1,310	50	15,850	25
5	2,200	0	184,100	2,500
6	100	40	1,360	20
7	2,200	25	66,840	1,400
8	8.300	50	121,100	4,000
9	270	400	170.600	1.500
10	1,580	25	81,590	125
Mean	2.115	120	83,330	1,600
Standard Error of Mean	755	62	19,125	586

Figs 3-6. Histopathological changes in different regions of the stomach of *Macropus fuliginosus* associated with nematode parasitism. 3, glandular epithelium of the parietal diverticulum showing dilated lumina (l), filled with eosinophilic secretion, and massive infiltrations of lymphocytes and plasma cells between glands; 4, squamous epithelium (s) of the saccular forestomach with minimal inflammatory change; 5, base of glands of cardiac mucosa from tubular forestomach showing diffuse infiltration of lamina propria with mononuclear cells (m, muscularis mucosae); 6, distal region of glands of cardiac mucosa showing diffuse infiltration of lamina propria with mononuclear cells. Scale bars: Fig. 3, 10 μm; Fig. 4, 100 μm, Figs 5, 6, 50 μm.

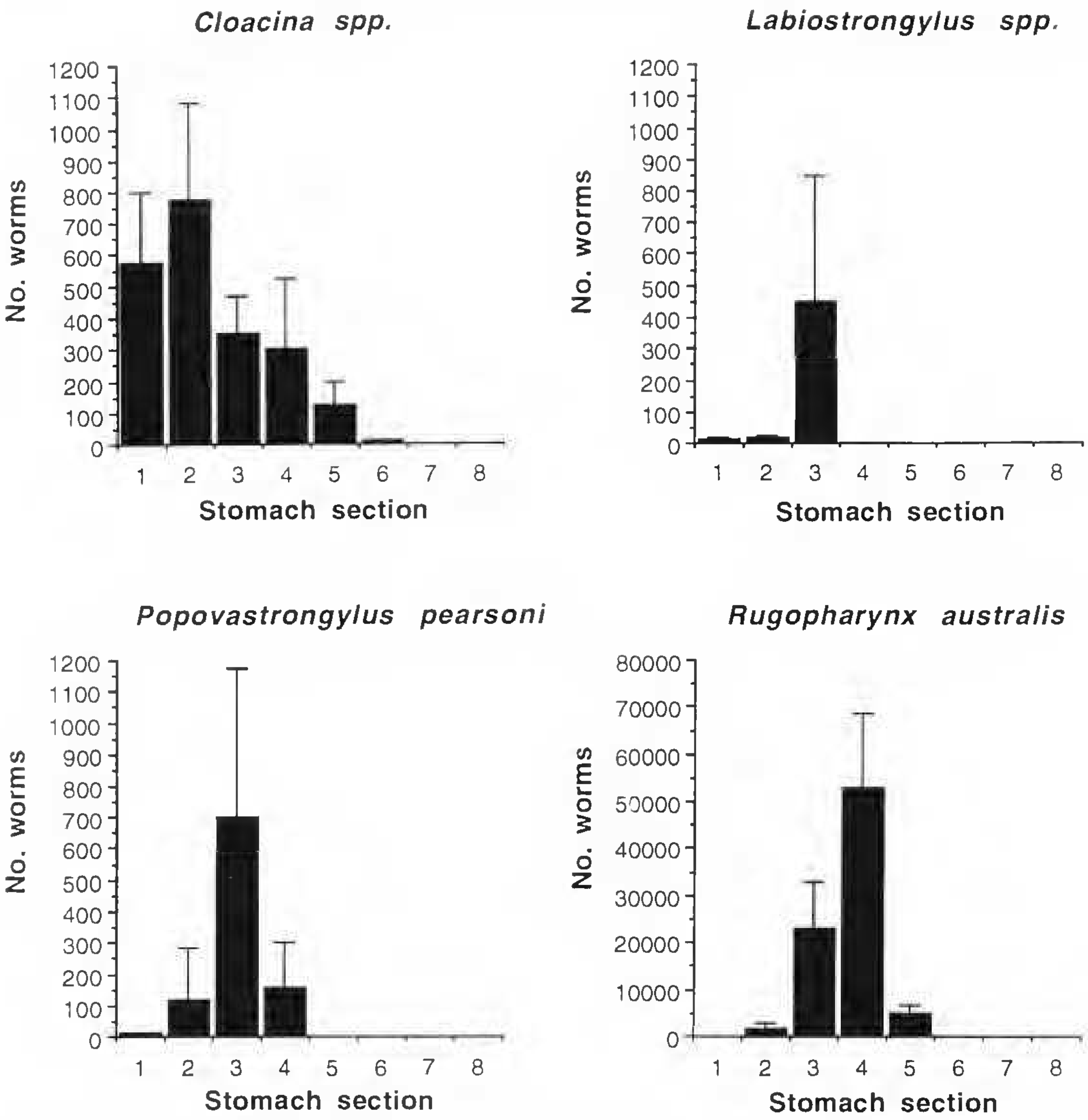

Fig. 7. Distribution of genera of strongyloid nematodes in eight regions of the stomachs of ten *Macropus fuliginosus* from Hattah, Victoria. (Bars represent standard errors of means.)

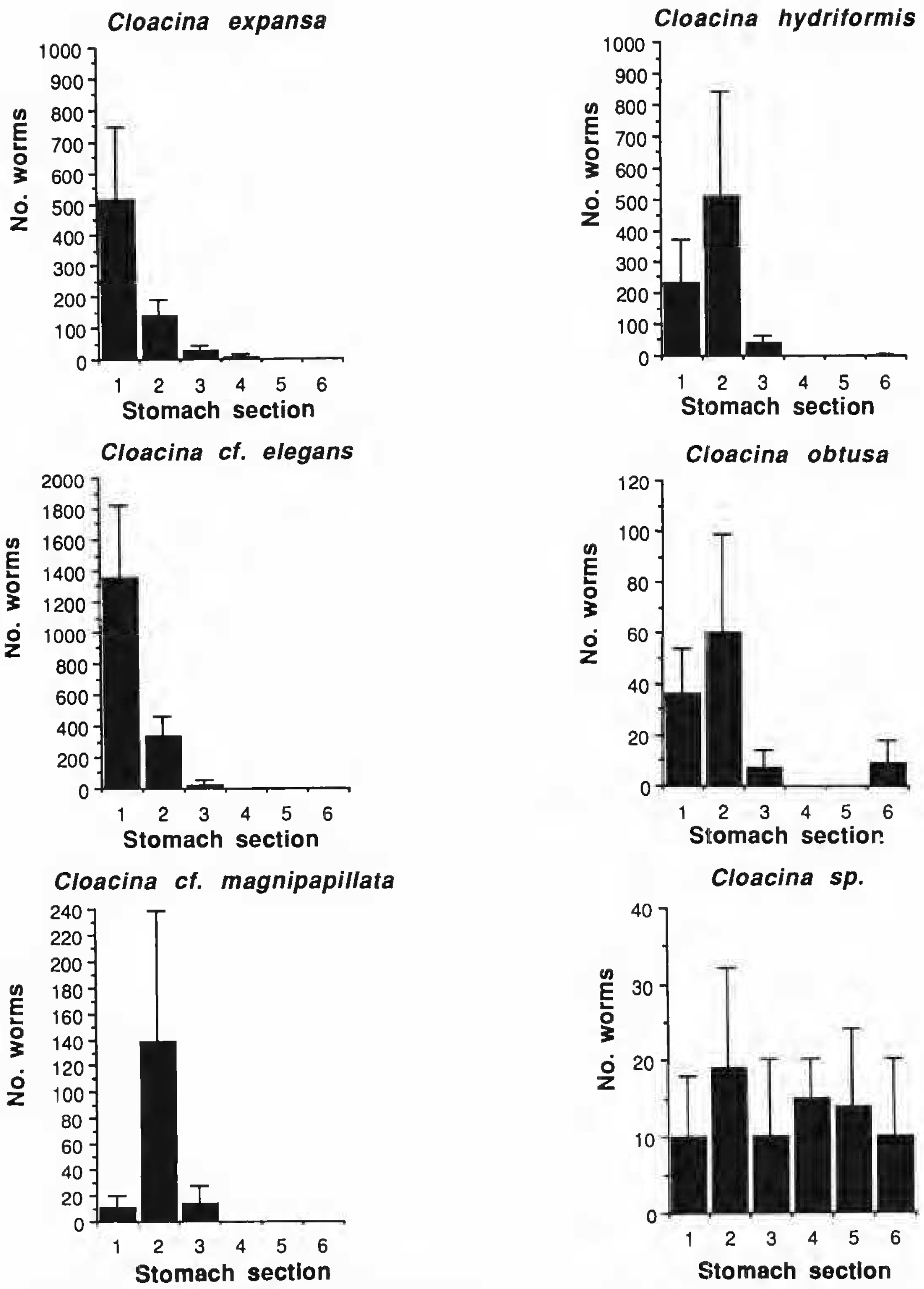

Fig. 8. Distribution of species of *Cloacina* in the eight divisions of the stomach of ten *Macropus fuliginosus* from Hattah, Victoria. (Bars represent standard errors of means.)

Discussion

The gastric anatomy of macropodids was reviewed by Hume (1982). The anatomy and histology of the stomach of the eastern grey kangaroo, *M. giganteus*, has been described previously (Schafer & Williams 1876; Langer *et al.* 1980; Dellow & Hume 1982). However there is no comparable information for the closely related species *M. fuliginosus*. In addition, while the histological and ultrastructural features of the stomach of the tammar wallaby, *Macropus eugenii*, have been described in detail (Gemmell & Engelhardt 1977), data for the eastern grey kangaroo are much more limited. We examined pathological changes in the mucosa associated with nematode parasitism and the distribution of nematodes in relationship to epithelial types and therefore an examination of both the gross and microscopic features of the stomach of *M. fuliginosus* was necessary. In this study, the gross anatomy of the stomach of *M. fuliginosus* did not differ significantly from that of *M. giganteus*. Proportions by weight of the three principal stomach regions in *M. fuliginosus*, saccular forestomach, tubular forestomach and hind stomach (22%, 74% and 4%), resembled that of *M. giganteus* closely (23%, 70% and 7%). The histological results from this study provide additional information on gastric anatomy of grey kangaroos. The most significant difference from earlier works is the recognition that the mucosa of the proximal diverticulum of *M. fuliginosus* is distinctly different histologically from that of the cardiac region and consists of elongate parallel glands producing an eosinophilic secretion. The same is true for *M. giganteus*, although the histological differences have not been reported in the literature, and both stomach regions have been considered to have an identical mucosal type (Hume 1982), a conclusion which would appear to be erroneous. Although anatomically distinctive, the function of this isolated area of glandular mucosa is unclear.

Anatomical terms applied to the stomachs of kangaroos are not consistent (see Hume 1982). The system of nomenclature suggested by Richardson (1980) as conforming most closely to *Nomina Anatomica Veterinaria* is suitable for descriptive purposes, but is not well suited to functional studies. The terminology used by Hume (1982) in which the stomach is divided into saccular forestomach, tubular forestomach and hindstomach is more appropriate when dealing with the distribution of nematodes and of epithelial types and has therefore been utilised in this study.

Determining the position of nematodes within an organ clearly requires very rapid fixation or immobilisation of the nematodes following the death of the host. With small host species, this has been achieved using rapid freezing (Schad 1963; Bush & Holmes 1986) or rapid immersion in fixative (Rohde 1980). With large hosts such as kangaroos, the technical difficulties are greater. The methods used in the past have been ligation of the stomach immediately following the death of the host in the laboratory (Smales & Mawson 1978b) or ligation following host death in the field (Dudzinski & Mykytowycz 1965; Arundel *et al.* 1979). Difficulties occur in accurately identifying anatomical "landmarks" and placing ligatures on stomachs under field conditions and therefore the approach taken here was to rapidly immerse the entire stomach in a large volume of formaldehyde solution and carry out its subdivision in the laboratory. That this did produce an accurate representation of the longitudinal distribution of nematodes was confirmed by comparison with data from the stomachs of two kangaroos which were ligated in the field prior to fixation.

In spite of technical limitations, each of the nematode genera exhibited a restricted localisation within the stomach. Data have been presented (Fig. 7) as absolute numbers of worms in each stomach section rather than number of worms per gram of stomach content (density). The only genus for which the distribution pattern is altered in comparing density rather than absolute numbers is *Cloacina* because of the high density of nematodes in section 1 of the stomach. *Cloacina* spp. were located primarily in the saccular forestomach with maximum densities in Section 1. *Labiostrongylus* spp. were also present in the saccular forestomach, but maximum numbers occurred in section 3 at the anterior end of the tubular forestomach. Both *Rugopharynx australis* and *Popovastrongylus pearsoni* occurred principally in the tubular forestomach and all strongyloid nematodes were absent from the hindstomach (sections 7-8), an area of the stomach characterised in macropodids by a low pH (Dudzinski & Mykytowycz 1965; Smales and Mawson 1978b), and inhabited only by the trichostrongyloid genus *Filarinema*.

The distribution of nematodes within the stomach of *M. fuliginosus* is similar to that reported for other kangaroo species. Smales & Mawson (1978b) found that *Cloacina* spp. were most abundant in the saccular forestomach of *M. eugenii* while *R. australis* was most abundant in the tubular forestomach. Likewise, Arundel *et al.* (1979) found that maximum numbers of *R. australis* occurred in the tubular forestomach of *M. rufus*. The distribution of *Labiostrongylus* spp. was restricted in *M. fuliginosus* (mainly in section 3) when compared with data from other hosts (Dudzinski & Mykytowycz 1965; Smales & Mawson 1978b) but this may be related to parasite density. The number of *Labiostrongylus* spp. in the present study was low (mean = 120, Table 3). Dudzinski & Mykytowycz (1965) divided their specimens of *M. rufus* infected with *L. longispicularis* into "heavily infected" (>200 worms) and "lightly infected" (<200 worms) hosts.

They showed that the maximum number of *L. longispicularis* always occurred in the tubular forestomach but that with increasing abundance, the numbers of nematodes in the saccular forestomach rose. If similar mechanisms operated in *M. fuliginosus*, then higher parasite densities would be expected to result in a significant increase in parasite numbers in sections 1 and 2 of the stomach. *P. pearsoni* in our study occurred predominantly in the tubiform forestomach (sections 4 and 5) but in *M. eugenii*, the same species occurs primarily in the sacciform forestomach (Smales & Mawson 1978b). The reasons for this difference are not known, but it may reflect differences in the anatomy and physiology of the stomachs of the grey kangaroos (*M. giganteus* and *M. fuliginosus*) when compared with that of *M. eugenii* (see Richardson 1980; Langer *et al.* 1980; Dellow 1982; Dellow & Hume 1982) or may be a function of host associations. *P. pearsoni* is a common and abundant parasite in *M. eugenii* (see Smales & Mawson 1978a). Its distribution in *M. fuliginosus* is much more restricted, being known only from Kangaroo Island, South Australia (Beveridge 1986), Kersbrook, South Australia (Wiesner, unpublished[1]) and Hattah, Victoria. It was not encountered in a survey of the parasites of 40 *M. fuliginosus* by Beveridge & Arundel (1979). *M. fuliginosus* may be an abnormal or unusual host for the parasite and this may be reflected in a differing distribution of the nematode in the stomach.

The distribution of congeneric parasite species was not investigated in the case of the two species of *Labiostrongylus* because of their relatively restricted distribution within the stomach. Of the several species of *Cloacina* present, only three, *C. expansa*, *C. hydriformis* and *C.* cf. *elegans* occurred at sufficiently high densities to permit comparisons. In each case, there was no evidence of differing distributions. Each parasite had a maximum density in the blind sac of the saccular forestomach. One *Cloacina* species occurred in sections 1 to 6 of the stomach, but in very low numbers only. The data therefore suggest that there is no or very little regional separation within the stomach when several congeneric species are present.

The lack of differences in the distribution of congeneric species of *Cloacina* contrasts with studies on the oxyuroid nematodes of tortoises (Schad 1963; Petter 1966) in which each nematode species was shown to have a restricted niche. The results obtained here, with no apparent niche segregation, are consistent with the hypotheses proposed by Rohde (1980) for monogenean parasites of fish, in which restricted niches were absent but aggregations of conspecific parasites were assumed to occur in order to facilitate reproduction (Rohde 1977). Competition was not considered to be a significant element in distributions as niches were super-abundant and were not saturated. In the specimens of *M. fuliginosus* examined, the numbers of nematodes present per kangaroo were low when compared with previous studies (Beveridge & Arundel 1979; Wiesner, unpublished[1]) in which total nematode numbers ranging from 300,000 to 500,000 were encountered in some kangaroos. These data imply that the numbers of niches available for most species of gastric nematodes in *M. fuliginosus* are large and if this is the case, competition would not be expected to be a major factor affecting nematode distributions. A far larger sample of kangaroos should be examined to test for evidence of interactions between component parasite taxa (Hoste & Cabaret 1992). However, little or no evidence of competition has been found in stomach-inhabiting nematodes in *M. rufus*, *M. giganteus* or *Petrogale* spp. (see Hoste & Beveridge 1993).

Histopathological changes in the gastric mucosa were restricted to diffuse infiltrations of mononuclear cells in the lamina propria between glands. Changes in the squamous epithelium were negligible. The mononuclear cellular infiltrations were diffuse and there was no apparent relationship with nematode distribution. Cellular changes in the lamina propria were most marked in the tubular forestomach, and it was here that the greatest numbers of nematodes were found. However, in the saccular forestomach where *Cloacina* spp. were dominant, the marked changes in the glandular epithelium compared with the lack of change in the adjacent squamous epithelium suggested that the type of epithelium present significantly influences the extent of pathological changes seen. In the fundus, an area essentially devoid of nematodes, no significant pathological changes were found.

In the pyloric antrum, focal lesions detected were caused by schizonts of a species of *Eimeria*. Although a number of species of this genus are known to occur in *M. fuliginosus* (see Barker *et al.* 1989), the species present in the pylorus could not be identified, because only the oocysts excreted in faeces have been described.

In the study of the pathological changes induced in the stomach of *M. giganteus* by nematodes, Arundel *et al.* (1990) commented on macroscopic lesions caused by *Labiostrongylus* spp., by *Strongyloides* sp. and by *Rugopharynx rosemariae*. None of the lesions they reported was found in *M. fuliginosus* at Hattah, although it is evident that the presence of *Cloacina* spp. and *R. australis* in the stomach resulted in a diffuse gastritis similar to the inflammatory changes induced by strongyloid nematodes in the large intestines of equids (Barker & van Dreumel 1985).

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[1] D. Wiesner. 1985. Comparison of helminth parasite burdens in western grey kangaroos, *Macropus fuliginosus* (Desmarest, 1822) grazing natural, improved and degraded pastures. Roseworthy Agricultural College, unpublished thesis.

The mean intensity of infection of kangaroos with gastric nematodes at Hattah (Table 3) (mean 87,200 nematodes) was similar to that (95,200) reported from 40 free-ranging *M. fuliginosus* collected in western Victoria and in South Australia by Beveridge & Arundel (1979). Given the high density of kangaroos at Hattah at the time of the collection of 78 per square kilometre (Morgan 1990), it was considered possible that parasite abundance might also be higher, as occurs in populations of *M. giganteus* (Arundel *et al.* 1990), but this was not the case. A more detailed study of the epidemiology of nematode infections in *M. fuliginosus* in western Victoria is required before the significance of the current data can be assessed.

Acknowledgements

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